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(54) Antenna device

(57) The invention relates to a device and a method to, in a digital mobile radio communication system which utilizes interleaving with restricted interleaving depth, reduce the influence of fading. This is effected by fading generated on uplink and/or downlink by transmitting on two or more antennas, at which the generated fading interferes with not generated fading (1) so that the duration of the generated fading in combination with the not generated fading (1) is considerably shorter than the interleaving depth (d).

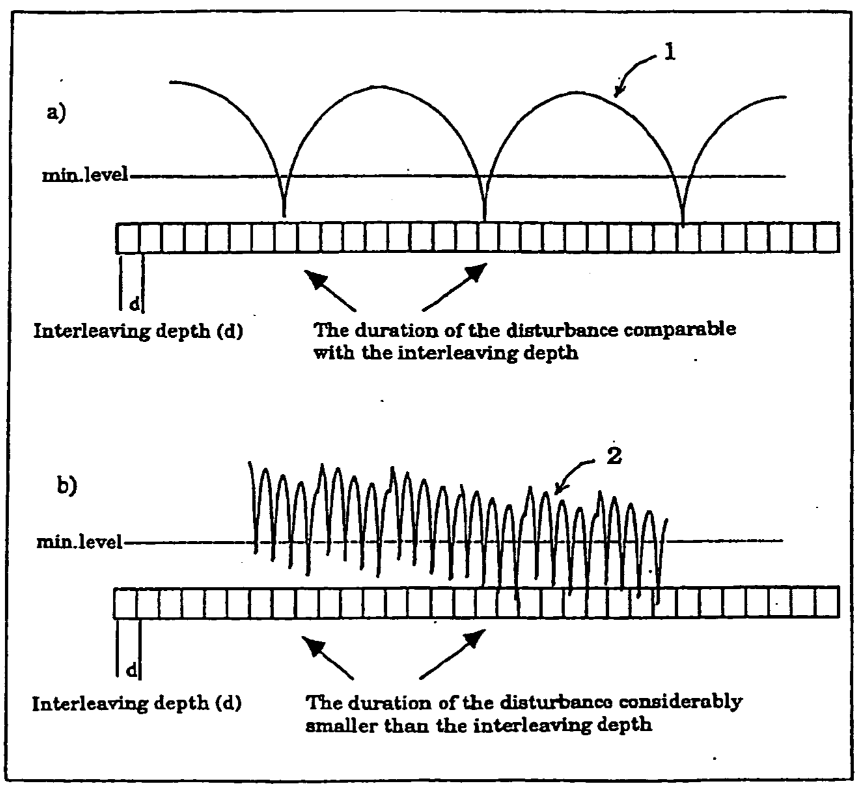

Figure 1

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Description

FIELD OF THE INVENTION

The present invention relates to a device and a method to, in a digital mobile radio communication system which utilizes interleaving with restricted depth of interleaving, reduce the influence of fading.

PRIOR ART

Fading consists of variations of the signal strength in time or space due to interference between different wave propagation paths and (varying) shadowing of the wave propagation paths.

High influence of fading can reduce the performance of the radio system such as smaller surface coverage, reduced transmission quality and lower capacity.

If no measures are taken at the system construction to reduce the influence of fading, the fading results in an increased cost for the operator if he/she shall be able to offer good surface coverage, high quality and capacity.

Interleaving is a method which is often used in digital radio systems, for instance GSM/DCS1800 and HIPERLAN (High Performance European Radio LAN), to reduce the influence of fading. The method implies that the information that shall be transmitted is spread out in a certain sequence over a certain time (a certain "depth"). At reception the sequence is utilized inversely to again collect the information. In that way, in the case of a short interference only, a smaller part of the information will be disturbed. One also achieves a form of averaging so the different adjacent information packets are disturbed to the same extent, which often is more favourable for the channel coding and the speech coding than that only certain parts are disturbed the more. To achieve a god gain, it is however neccessary that the duration of the disturbance is considerably shorter than the time over which the distribution is made. This condition is however not fulfilled in GSM/DCS1800 respective HIPERLAN for the applications where the user (the terminal) moves slowly, for instance hand-carried terminals which are still or only mowing in walking rate. In these applications the terminal will not have time to move out from the disturbance during the time interval which constitutes the interleaving depth or the distribution time.

For GSM/DCS1800 it is above all the downlink, i.e. the link from the base station to terminal that is critical. This depends on that one in these systems does not have any antenna diversity in the downlink. From a more general point of view one can say that this restriction is valid for all mobile systems the uplink and downlink of which for one and the same communication is uncorrelated regarding the fading, i.e. the base station cannnot, based on measuring of the uplink, predict antenna selection for the downlink.

One more problem for GSM/DCS1800 is that frequency jumps are insufficient in urban environment and indoor environment to increase the interleaving gain. This is due to that feasible jump interval is too small in relation to the correlation bandwidth in these environments.

Finally it should be mentioned that for GSM/DCS1800 one at present has to utilize higher output power in downlink in comparison with uplink, to compensate the lack of antenna diversity in downlink. High base station output power however reduces the system capacity. Further, the important miniaturization of the base stations is made more difficult.

At a preliminary investigation which was performed to find out whether previously technology solves above mentioned problems, the following documents were found.

Document US-A-4 661 993 shows a method to increase performance in a radio system at fading. According to the document either the difference in amplitude or in phase is varied between the antennas. The method is also applicable on the receiver side.

The document GB-A-2 135 544 relates to a variant of the method to vary the amplitude between the antennas. In this document the carrier frequency differs between the two antennas with a few Hz to avoid stationary "dead spots".

The document US-A-3 922 685 combines antenna changing and variation of the phase.

The document FR-A-2 215 759 shows a radio transmitter which successively changes between three antennas. If the speed of the antenna changing is sufficiently high, the probability that a mobile will land up in a "dead point" is reduced.

Document EP-A-568 507 shows a way to reduce the effect of fading by varying the antenna characteristics, i. e. the appearance of the antenna lobe. This is achieved by successively connecting passive antenna elements.

In document US-A-5 267 268 one has reduced the risk for poor reception at fading by step by step vary the polarization of the transmitted signal.

These documents, however, do not describe any solutions to the above mentioned problems.

CONCLUSION OF THE INVENTION

The aim with the present invention consequently is to attend to that the duration of the fading (the disturbance) is considerably shorter than the time over which the interleaving (the distribution) is made; this is normally not the case in GSM/DCS1800 respective HIPERLAN for the applications where the user of the mobile terminal stands still or moves at walking rate.

One further aim with the present invention is to clear away or minimize the restriction which is valid for all mobile systems the uplink and downlink of which for one and the same communication is uncorrelated with re-

gard to fading. For GSM/DCS1800 this is due to that one does not have any antenna diversity in the downlink.

One more aim with the present invention is that one in GSM/DCS1800 clears away the problems of increasing output power in downlink compared with uplink to compensate for lack of antenna diversity in downlink, which results in higher system capacity and besides facilitates for the important miniaturization of the base stations.

These aims are achieved by a device and a method according to the present invention which, in a digital mobile radio communication system utilizing interleaving with restricted interleaving depth, generates fading which interferes with not generated fading so that the duration of the generated fading in combination with the not generated fading becomes considerably shorter than the interleaving depth.

SHORT DESCRIPTION OF THE DRAWINGS

The present invention will now be described in more details with references to the enclosed drawings.

Figure 1 shows example of how fading has been added in b) compared with a).

Figure 2 shows a device according to the invention for transmission /reception where both amplitude and phase are varied.

Figure 3 shows a device according to the invention for transmission/reception where only the amplitude is varied.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The invention relates to a device and method to reduce the influence of fading over a digital mobile radio communication which utilizes interleaving with restricted interleaving depth, at which the device generates fading which interferes with not generated fading so that the period time for the generated fading in combination with the not generated fading becomes considerably shorter than the interleaving depth (see Figure 1).

Figure 1a shows a system where the time period for the fading 1 (the disturbance) is much longer than the interleaving depth (d). This situation is very unfavourable at applications where the user (the mobile terminal) stands still or is moving slowly; the user will not have time to move out from the disturbance during the time interval which constitutes the interleaving depth (the distribution time), which results in that the quality of the received signal becomes poor. Figure 1b, on the other hand, shows a system where fading has been added to the previous fading 1. By that the fading is shortened and concentrated, at which the interleaving depth is increased in relation to the duration of the fading dips (the disturbances); this created interference fading 2 consequently has a higher frequency and a much shorter period time than the previous fading 1. In this case the user of the mobile terminal will have time to move out from the disturbance during the time interval which constitutes the interleaving depth.

The Figures 2, 3 show examples of two devices which are used to generate fading. The receivers in the Figures 2, 3 utilize the two antennas for antenna diversity. Instead of duplex filter, separate antennas can be used for transmission respective reception. In Figure 2 fading is generated by varying phase and/or amplitude, whereas in Figure 3 fading is generated by only varying the amplitude; this will be described in details in the following.

The invention generates fading on uplink and/or downlink by transmitting on two or more antennas (see Figure 2, 3) acccording to the following, alternative methods which will now be described.

Method 1

Fading is generated by changing antenna over which transmission is made. The changing of antennas is performed at certain intervals which can be fixed or not fixed. At not fixed intervals, the intervals can either be varied at random or in a deterministic way.

One example of a deterministic method for deciding the changing interval will now be described. Measuring is made of the period time for the fading 1, which period time is compared with the interleaving depth (d). The antenna changing interval is decided so that the period time for the generated fading in combination with the not generated fading 1 becomes considerably shorter than the interleaving depth (d). Determination of the changing interval can be made for each individual user.

Method 2

Fading is generated by varying difference in phase and/or amplitude between the antennas. Ideally the difference in phase should be possible to vary linearly and continuously. In practice it can however be suitable to divide the phase shifts into discrete intervals (simpler implementation).

The time intervals (tphase) which shall elapse during a 360° phase shift can be determined deterministically. Measuring is made of the period time for the fading 1, which period time is compared with the interleaving depth (d). The time interval (tphase) is determined so that the period time for the generated fading in combination with the not generated fading 1 becomes considerably shorter than the interleaving depth (d). Determination of the time interval (tphase) can be made for each individual user, but can also be the same for all users.

The present invention has been used in for instance GSM and in HIPERLAN with very satisfactory result.

For GSM interleaving will give a good gain if the mobile terminal moves with a higher speed than 50 km/h. If we suppose that the mobile terminal moves in an environment without clear view with so called short fading,

this means that the fading dips on an average are separated about 0,15 cm. This corresponds to a time interval of about 10 milliseconds between the dips. Let us now suppose that the user of the mobile terminal leaves the car to walk at about 5 km/h. The time intervals between the dips are now about 100 milliseconds on an average, which is more than GSM'S interleaving depth. If we chose tphase to 11 milliseconds then the mobile terminal will experience fading with an average period time as if it was travelling at a rate of 50 km/h.

HIPERLAN has a maximal interleaving depth (d) of about 1 millisecond. If we suppose that the terminal moves at a rate of about 1 m/s, this means that the time intervals between the fading dips on an average is about 50 milliseconds (at the carrier frequency 5 GHz). Consequently the interleaving depth is too small. If one utilizes the invention with the time interval (tphase) less than 1 millisecond, considerably better performance is achieved.

Fading can, as has been mentioned above, be generated by varying the signal amplitude for either one or for all antennas (see Figure 2, 3). Further, the amplitude variation can be combined with phase variation (see Figure 2).

The time interval (tamp) which shall elapse during the amplitude variation between two local amplitude maxima can be determined deterministically: Measuring is made of the period time of the fading 1 which can be compared with the interleaving depth (d). The time interval (tamp) is determined so that the period time for the generated fading in combination with the not generated fading 1 becomes considerably shorter than the interleaving depth (d). Determination of the time interval (tamp) can be made for each individual user, but can also be the same for all users. The amplitude variation should preferably be made continuously, but can also be made in discrete steps.

A simple but effective embodiment of the invention is that the amplitude variation is made on one of the antennas. The amplitude is varied continuously between a maximum (the same amplitude as of the antenna with constant amplitude) and a minimum, by means of a variable attenuator/amplifier A in one of the antennas (see Figure 3).

The antennas which are utilized to generate fading shall be separated in the same way as if they are only utilized to create antenna diversity, i.e. the antennas shall be as uncorrelated as possible and the average of the antennas shall be as equal as possible.

It should be realized that an alternative to to utilize separate antennas is to use an antenna which comprises two or more antenna elements. This means that the invention utilizes controlling of two or more antenna elements within one and the same antenna.

Generating of fading shall be made in the link direction or link directions which do not utilize antenna diversity. For for instance GSM/DCS1800 generating of fading should be made in downlink. The same antennas for generating of fading are utilized as those at the base station for antenna diversity in uplink. By that a considerably better balance in the link budget between uplink and downlink is achieved (see Figure 2, 3).

As has previously been mentioned, the advantage of the present invention increases the slower the user of the mobile terminal moves. Examples of systems (GSM and DCS1800) have been described which are of great current interest for use of the invention, especially in indoor applications and micro cell applications. These applications of mobile telephony in indoor environments and in micro cell environments are considered to be of very big importance for the future growth of the mobile telephony. The present invention therefore will have an especially great importance due to that one in these applications make very great demands upon quality. This will in the long run also be valid for HIPERLAN.

The above descibed is only to be regarded as embodiments of the present invention, and the scope of protection of the invention is only restricted by what is indicated in the following patent claims.

Claims

1. Device to, in a digital mobile radio communication system utilizing interleaving with restricted interleaving depth, reduce the influence of fading, **characterized** in that it generates fading which interferes with not generated fading (1), so that the duration of the generated fading in combination with the not generated fading (1) is considerably shorter than said interleaving depth (d).

2. Device according to patent claim 1, **characterized** in that it generates fading on uplink and/or downlink by transmitting being performed on two or more antennas (3, 4, 5, 6).

3. Device according to patent claim 2, **characterized** in that it changes between antennas (3, 4, 5, 6) over which transmission is made.

4. Device according to patent claim 3, **characterized** in that it attends to changing between the antennas (3, 4, 5, 6) with constant or not constant time intervals, at which at not constant time intervals the device varies said time interval at random or in a deterministic way.

5. Device according to patent claim 4, **characterized** in that it measures the period of the not generated fading (1) and compares this with the interleaving depth (d), after which the device determines an antenna changing interval so that the period time for the generated fading in combination with the not generated fading (1) is considerably shorter than the interleaving depth (d).

6. Device according to patent claim 5, **characterized** in that it attends to that the antenna changing interval can be made for each individual user.

7. Device according to patent claim 2, **characterized** in that it generates fading by varying the phase of a signal which is transmitted from one of the antennas (3, 4), or by varying the phase of just any number of signals which are transmitted from the antennas (3, 4).

8. Device according to patent claim 7, **characterized** in that it measures the period time of the not generated fading 1 and compares this with the interleaving depth (d), whereupon the device deterministically determines a time interval (tphase) which shall elapse during a 360° phase shift, so that the period time for the generated fading in combination with the not generated fading (1) is considerably shorter than the interleaving depth (d).

9. Device according to patent claim 8, **characterized** in that it attends to that determination of time interval (tphase) can be made for each separate individual.

10. Device according to patent claim 2, **characterized** in that it generates fading by varying the amplitude of a signal which is transmitted from one of the antennas (3, 4, 6) or by varying the amplitude of just any number of signals which are transmitted from the antennas (3, 4, 6).

11. Device according to patent claim 10, **characterized** in that it measures the period time for the not generated fading (1) and compares this with the interleaving depth (d), whereupon the device deterministically determines a time interval (tamp) which shall elapse during the amplitude variation between two local amplitude maxima so that the period time for the generated fading in combination with the not generated fading (1) is considerably shorter than the interleaving depth (d).

12. Device according to patent claim 7 or 10, **characterized** in that it in order to generate fading attends to both amplitude variation and phase variation of the signal/signals.

13. Device according to patent claim 10, **characterized** in that it varies the amplitude of the signal continuously between a maximum and a minimum by means of a variable attenuator/amplifier in one of the antennas (6).

14. Device according to any of the previous patent claims, **characterized** in that antennas (3, 4, 5, 6) which are utilized to generate fading are separated in the same way as when they are utilized to effect antenna diversity.

15. Device according to patent claim 14, **characterized** in that the antennas (3, 4, 5, 6) shall be as uncorrelated as possible and their average shall be as equal as possible.

16. Device according to patent claim 14 or 15, **characterized** in that it utilizes an antenna comprising two or more antenna elements, at which the device utilizes control of two or more antenna elements within one and the same antenna.

17. Device according to any of the patent claims 14-16, **characterized** in that it generates fading in the link direction or link directions which do not utilize antenna diversity.

18. Device according patent claim 17, **characterized** in that it generates fading in downlink at utilization of GSM/DCS1800.

19. Device according to any of the patent claims 14-18, **characterized** in that it utilizes the same antennas for generation of fading as those which are utilized at the base station for antenna diversity in uplink.

20. Method to, in a digital mobile radio communication system which utilizes interleaving with restricted interleaving depth, reduce the influence of fading, **characterized** in that fading is generated which interferes with not generated fading (1) so that the duration of the generated fading in combination with the not generated fading (1) is considerably shorter than said interleaving depth (d).

21. Method according to patent claim 20, **characterized** in that fading is generated on uplink and/or downlink by transmission being made on two or more antennas (3, 4, 5, 6).

22. Method according to patent claim 21, **characterized** in that fading is generated by means of changing with constant or not constant time intervals between the antennas over which transmission is made.

23. Method according to patent claim 22, **characterized** in that a deterministic determination of the changing interval is effected by a measuring of the period time of the not generated fading (1), whereupon said measuring is compared with he interleaving depth (d), at which if said measuring of the period time of the not generated fading (1) is bigger than the interleaving depth (d). the time interval for the changing between the antennas is determined so that the period time for the generated fading in combination with the not generated fading (1) is

considerably shorter than the interleaving depth (d).

24. Method according to patent claim 21, **characterized** in that the fading is generated by varying difference in phase between the signals which are transmitted from the antennas (3, 4).

25. Method according to patent claim 24, **characterized** in that a deterministic determination of a time interval (tphase) which shall elapse during a 360° phase shift is effected by a measuring of the period time of the not generated fading, whereupon this measuring is compared with the interleaving depth (d), at which if said measuring of the period time for the not generated fading (1) is bigger than the interleaving depth (d), the time interval (tphase) is determined so that the period time for the generated fading in combination with the not generated fading (1) is considerably shorter than the interleaving depth (d).

26. Method according to patent claim 25, **characterized** in that determination of tphase can be made for each individual user, but can also be the same for all users.

27. Method according to patent claim 21, **characterized** in that fading is generated by varying the signal amplitude of one of the antennas (3, 4, 6) or of all antennas (3, 4, 6).

28. Method according to patent claim 27, **characterized** in that a deterministic determination of a time interval (tamp) which shall elapse during amplitude variations between two local amplitude maxima is effected by a measuring of the period time of the not generated fading (1), whereupon this measuring is compared with the interleaving depth (d), at which if this is measuring is longer than the interleaving depth (d), the time interval (tamp) is determined so that the period time for the generated fading in combination with the not generated fading (1) is considerably shorter than the interleaving depth (d).

29. Method according to patent claim 28, **characterized** in that the determination of the time interval (tamp) can be made for each individual user, but can also be the same for all users.

30. Method according to patent claim 29, **characterized** in that the amplitude variation is only made on signal of one of the antennas (6).

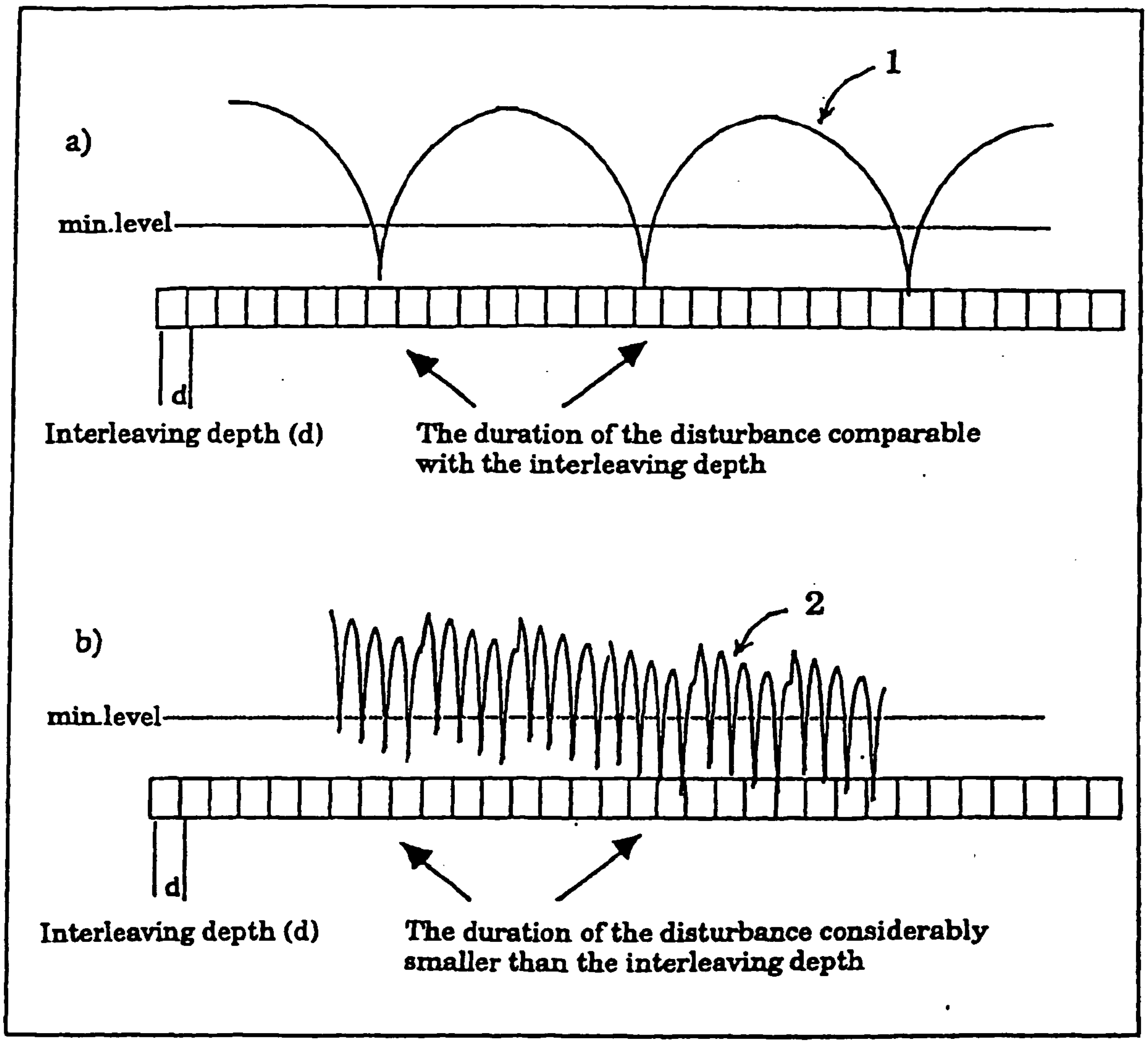
1
a)
min.level
d
Interleaving depth (d)
The duration of the disturbance comparable with the interleaving depth
2
b)
min.level
d
Interleaving depth (d)
The duration of the disturbance considerably smaller than the interleaving depth

Figure 1

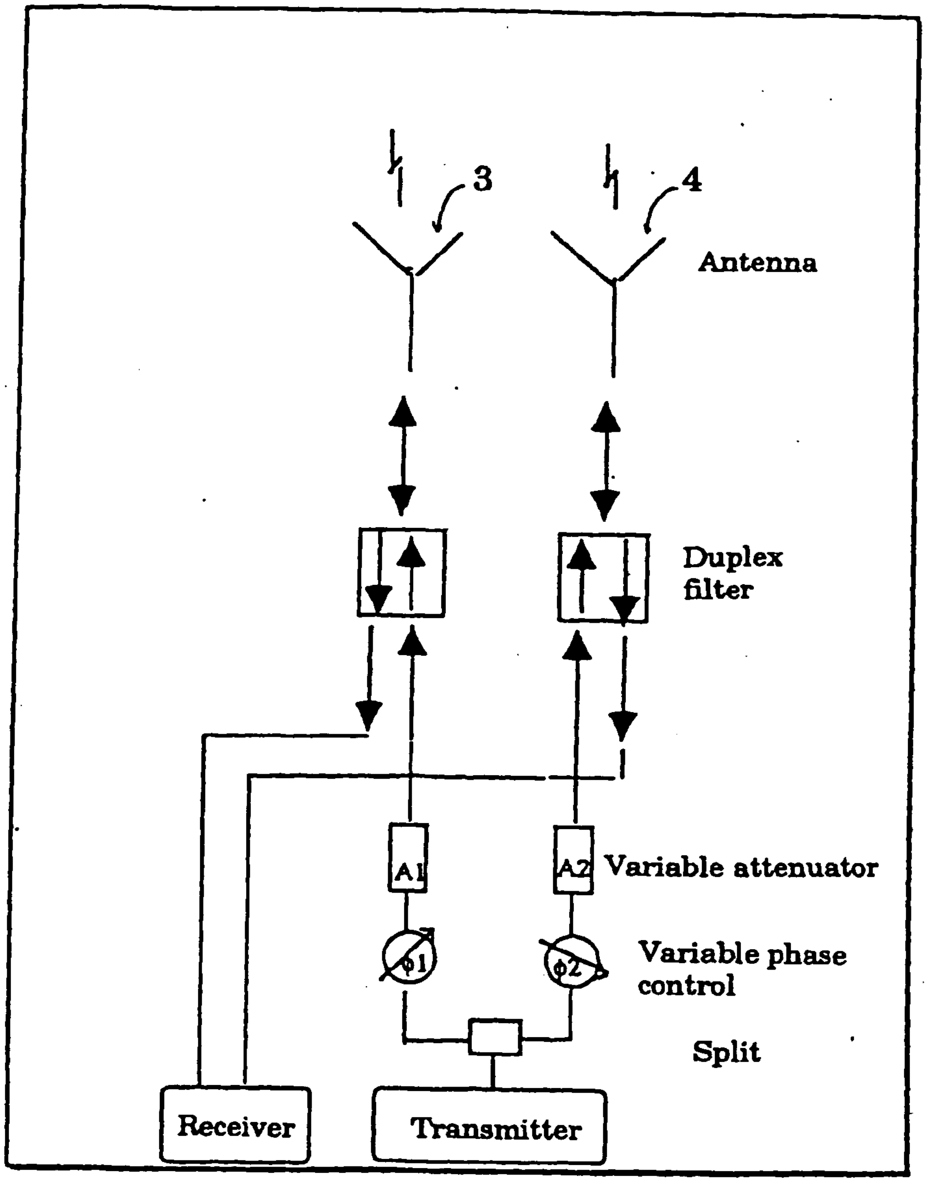
3
4
Antenna
Duplex filter
A1
A2
Variable attenuator
φ1
φ2
Variable phase control
Split
Receiver
Transmitter

Figure 2

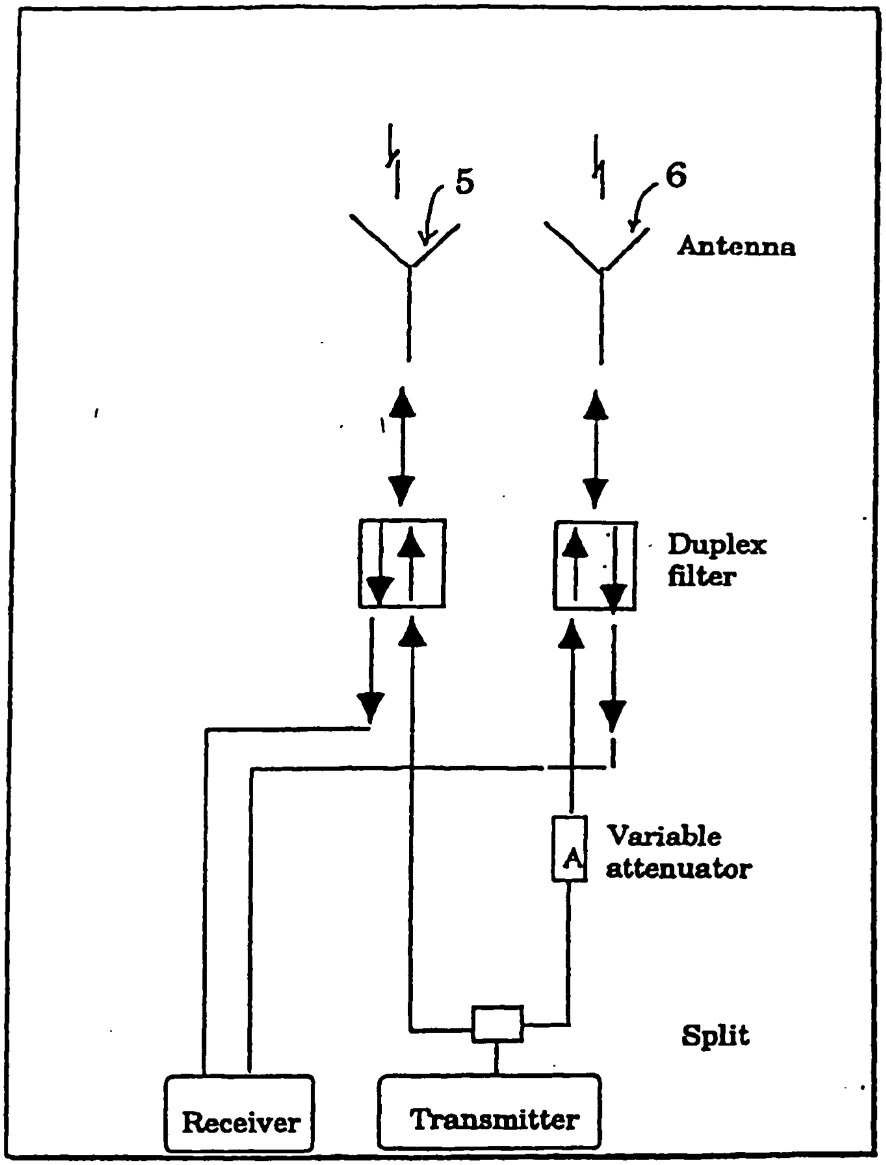
5
6
Antenna
Duplex filter
Variable attenuator
A
Split
Receiver
Transmitter

Figure 3